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ABSTRACT

An investigation of the relative speed with which listeners comprehend and answer subject- and object-questions in English, German, and Dutch is reported. The primary data are the times required to answer pairs of questions such as, "Who is chasing the boy?" and "Who is the boy chasing?" and their counterparts in Dutch and German. In the three languages, the corresponding questions express the same semantic content, but in three different syntactic forms. The subject/object functions are signaled by word order in English, morphology in German, and context in Dutch. By noting which of the forms is responded to more rapidly in each language, insight may be gained into the roles these three kinds of cues play in comprehension. Subjects were adults and 7-year-olds tested in universities and schools in their native countries. Results showed that subject-questions are answered faster in Dutch and German, but object-questions are answered faster in English. It is suggested that this shows comprehension to be a highly interactive process drawing on multiple kinds of cues. However, an ambiguity in the English language results suggest a need for further investigation. (MSE)

Working Paper No. 309

INTERPRETING WH-QUESTIONS IN ENGLISH, GERMAN, AND DUTCH

by

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Report from the Project on
Studies in Language: Reading and Communication

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owledgements

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Abstract

This investigation concerns the relative speed with which listeners comprehend (and answer) subject- and object-questions in English, German, and Dutch. The primary data are the times required to answer pairs of questions like

Who is chasing the boy?

Who is the boy chasing?

and their counterparts in Dutch and German. In the three languages, the corresponding questions express the same semantic content, but in three different syntactic forms. The subject/object functions are signalled by word order in English, morphology in German, and only by context in Dutch. Thus by noting which of the two forms is responded to more rapidly in each language, we may gain some insight into the roles that these three kinds of cues play in the comprehension process.

It turns out that subject-questions are answered faster in Dutch and German, but object-questions are answered faster in English. We think this outcome favors the view that comprehension is a highly interactive process which draws upon multiple kinds of cues, but we also note an ambiguity in the English results, and consequently a need for further investigation.

Interpreting WH-Questions in English, German, and Dutch

Peter A. Schreiber and Charles Read

Introduction

Despite uncertainty about many substantive issues, much current work in linguistics and psycholinguistics proceeds from the assumption that the cognitive mechanisms which are involved in real-time syntactic processing must be at least partly independent of the abstract linguistic system, although tacit knowledge of the latter may be intimately implicated in the process. On this view, the grammar is an abstract device that specifies the class of well-formed sentences and assigns them structural descriptions. The actual synthesis and analysis of utterances are then seen as involving additional principles (Chomsky, 1965; Clark & Clark, 1977; Fodor, Bever, & Garrett, 1974; Kimball, 1973; Yngve, 1960). Hence, models that purport to represent what speakers do in producing or comprehending sentences must involve mechanisms that at least supplement the purely grammatical ones.

A partial model for the processing of syntactic structure is found in the set of extensive proposals made by T. Bever, J.A. Fodor, and their colleagues in various reports, most notably Bever (1970) and Fodor, Bever, and Garrett (1974). One of their major hypotheses is that the syntactic processing of a sentence relies heavily on a system of tacit heuristic parsing strategies for making direct inductions about the base (deep) structures of sentences. These perceptual strategies are not themselves rules of grammar; they are explicitly intended to be heuristic and probabilistic in nature. Several types of strategies are proposed: some are intended as universal principles for assigning a general syntactic organization to sentences, others are

language-specific strategies, yet others are claimed to be linguistically special cases of cognitive principles governing behavior in general. Central among their substantive proposals is the claim that the universal basis for processing sentences involves isolating the clauses that comprise them. The clause (actually the deep structure clause, which they call a sentoid) is held to be the primary processing unit, the unit of perceptual integration.

The model of syntactic processing that emerges from Bever (1970) can be outlined as follows. As the incoming sentence is received, it is placed in a short-term memory storage where the parts that constitute each sentoid are held. (It is assumed that, for the purposes of syntactic parsing, sentences or, strictly speaking, utterances have already received a lexical analysis.) The actual syntactic processing stage involves grouping the parts together into sentoids and determining the relationship of the various sentoids to one another. As soon as each sentoid is constructed and its relationships determined, it is dismissed from short-term memory and submitted for semantic processing. The general processing model and the notion that sentoids are the basic perceptual units at the level of syntax are taken to be universal; however, the specific strategies used in determining the clausal units, strategies that presumably come into play during actual syntactic processing, must be language-specific. Among the proposed strategies, a central one is what Fodor et al. (1974, p. 344 ff.) call the "canonical sentoid strategy," which asserts that when the listener encounters a NP V (NP) sequence in the surface form of an input sentence, he should assign this sequence an analysis as subject, verb (and object), respectively, of the underlying sentoid. It is of

course clear that this general strategy would need to be supplemented by various others; indeed, Bever (1970) contains a more detailed set of strategies whose effect is equivalent to that of the canonical sentoid strategy (CSS). These strategies have been critically scrutinized by several writers; Frazier (1979) presents telling arguments of both a methodological and substantive nature against Bever's proposals. Nonetheless, the general force of the CSS has a certain intuitive appeal; as Bever, Fodor, and others have suggested, it implies that the processing of sentences with the canonical NP V (NP) sequence (with the first NP interpreted as subject) should be easier than the processing of sentences with a noncanonical order. Fodor et al. (1974, p. 347) claim that "the stages in processing appear to be to first reduce the input to the form NP V (NP) and then apply the canonical sentoid strategy." An immediate implication of this is that, ceteris paribus, sentences where, say, the object precedes the subject should be harder and/or take longer to process than ones in which the elements are already in the canonical shape. In fact, Fodor et al. (p. 346) propose the "interesting speculation that 'Who has John kissed?' ought to be harder than 'Who has kissed John?' if the canonical sentoid theory is generalizable to sentences which do not contain embeddings."

The Problem

As is implied by the speculation of Fodor et al., there is some evidence that the CSS accounts for certain aspects of the processing of embedded sentences, specifically relative clauses for which it has been found that when the clause is center-embedded, subject relatives are more easily processed

than object relatives. This result, however, does not provide unequivocal support for the CSS, for the same prediction would follow from other, quite different theories of processing, e.g., Kimball (1973). In fact, most explicit accounts of sentence processing of which we are aware would seem to lead to similar predictions; aside from Kimball's theory, this would include J.D. Fodor (1979), Wanner and Maratsos (1978), and Bresnan's (1978) interpretation of the Wanner and Maratsos proposals. While not subscribing to the CSS itself, Wanner and Maratsos present evidence that supports the view that subject relatives are more easily processed than other types. Finally, similar predictions would appear to follow from the proposals concerning NP accessibility made by Keenan and Comrie (1977). In view of this, it seems appropriate to attempt to test the prediction directly by examining comprehension of simple and also embedded information (WH) questions. Specifically, it would seem that if the CS approach is correct, subjects (Ss) ought to respond more quickly to subject questions like Who is kissing the woman? than to object questions like Who is the woman kissing?, for only the first conforms to the canonical order. The research reported below originated as an attempt to examine precisely this claim. Our hypothesis was that if the CS approach is right, Ss' latencies to (correct) response should be shorter when the questioned constituent is a subject rather than an object in both simple and embedded information questions. Moreover, we wished to examine the results with both children and adults, since we are interested in determining whether significant differences exist between child and adult syntactic processing. Finally, we felt it would be valuable to examine the issue cross-linguistically, both because there have been few controlled cross-linguistic

processing studies and because important insight into the CS theory might be gained if the languages compared differed substantially in the way they signal the basic clausal relations. In particular, we chose to compare results obtained from English, German, and Dutch native speakers because these three languages differ interestingly in terms of syntactic (word order) and morphological (and even prosodic) signals of structure.

The specific differences in the formation of simple and embedded WH-questions in the three languages are illustrated by the following sentences:

(1) English

a. Who is kissing the woman?

b. Who is the woman kissing?

c. Tell me who is kissing the woman.

d. Tell me who the woman is kissing.

(2) German

a. Wer küsst die Frau?

b. Wen küsst die Frau?

c. Sag mir, wer die Frau küsst.

d. Sag mir, wen die Frau küsst.

(3) Dutch

a. Wie zoent de vrouw?

b. Wie zoent de vrouw?

c. Zeg me wie de vrouw zoent.

d. Zeg me wie de vrouw zoent.

In English the contrast between subject and non-subject WH-questions (both simple and embedded) is signalled primarily by order: when the WH-word refers

not produce absolute differentiation.

As suggested earlier, there is some evidence, e.g., Wanner and Maratsos (1978), that subject relatives are more easily processed than object relatives. This is consistent with the CS approach, but it would also be consistent with the claim that subject relatives (and subject WH-words in general) are inherently more easily accessible, or even with the claim that listeners have a disposition, preference, or expectation for a subject-interpretation of WH-words. In fact, the Dutch data discussed in Read, Kraak, and Boves (1979) supports this last interpretation. One appeal of a cross-linguistic comparison was that it seemed to provide a way of distinguishing between the predictions made by the CS approach and the generally greater ease of or preference for subject interpretations. Note that these two are confounded in English: the CS approach claims that a major step in processing is to convert the surface input into a form consistent with canonical SV (O) order, so that, say, SVO sequences should be easier or faster to process than OSV sequences, ceteris paribus. This predicts an advantage for subject questions and relatives.

German differs from English in morphologically marking case on all NPs; moreover, although there are unmarked orders in German clauses, it has been argued (e.g., by Vennemann, 1974) that German main clauses are best viewed as having not a basic Subject Verb Complement order but rather a Topic Verb X order, where the Topic can be basically any constituent, and where X corresponds to the remainder of the structure. For example, all four of the following are perfectly normal German sentences:

(4) a. Der Mann küsst die Frau. 'The man (nom) kisses the woman (acc).'

b. Die Frau küsst der Mann. 'The woman (acc) kisses the man (nom).'
viz. The man kisses the woman.

c. Die Frau küsst den Mann. 'The woman (nom) kisses the man (acc).'

d. Den Mann küsst die Frau. 'The man (acc) kisses the woman (nom).'
viz. The woman kisses the man.

A more elaborate example, modelled after Vennemann (1974) is the following:

(5) a. Fritz muss gestern seinen Freunden das Buch gegeben haben.
'Fred must yesterday his friends the book given have.'
viz. Fred must have given his friends the book yesterday.

b. Gestern muss Fritz seinen Freunden das Buch gegeben haben.

c. Seinen Freunden muss Fritz gestern das Buch gegeben haben.

d. Das Buch muss Fritz gestern seinen Freunden gegeben haben.

The facts of German are even further complicated. First, in main clauses the main verb is in second position only if there are no "auxiliary" verbs; if there are, the main verb occurs generally in clause-final position; this so-called brace construction is illustrated in (6).

(6) Er hat das Buch nicht gelesen. 'He has the book not read.'
viz. He did not read the book.

Moreover, in subordinate clauses, the normal order is subject object verb, as illustrated in (2c-d) above. There are other rearrangements and permutations, but the basic point is that while certain orders may be unmarked in certain clause types, it seems doubtful that a potential German counterpart of the CSS would be framed in terms of word order; rather, a strategy using morphological categories would apply more generally. If that strategy refers to morphological

categories like [+nominative], it follows that the stages of processing German would differ to some extent from those for English. Recall that Fodor et al. claim that "the stages in processing appear to be to first reduce the input to the form NP V (NP) and then apply the canonical sentoid strategy," which asserts that a NP V (NP) sequence should be assigned an analysis as subject, verb (and object), respectively, of the underlying sentoid. (Fodor et al. do not qualify this claim so as to indicate whether they mean it to be universal or language-particular; for the present, we assume that the first part of the process, reducing the input to some canonical form, is language-particular, as is the input statement for the CSS itself. The output of the CSS, that is the mapping of a canonically reduced surface form onto an appropriate set of grammatical relations, is presumably to be defined in universal terms.) For German, the first stage reduction of input would presumably be stated in terms of the relevant morphological categories rather than in terms of order (sequence of syntactic categories or phrase types). This first stage might take very roughly the form of (7):

(7) Given a potential sentoid in the surface structure, reduce the input to the form NP [+nom], V, (NP [+acc]).

The actual statement of the CSS for German would then be roughly given as (8):

(8) Assign a NP [+nom] the analysis subject, assign a NP [+acc] the analysis object, and assign V the analysis predicate.

Note that neither of these statements need be interpreted as imposing a linear ordering of elements into canonical sequence. If they are not so interpreted, no prediction of greater ease for subject relatives or WH-words is made.

The situation in Dutch is intermediate between English and German.

Dutch NPs are generally not morphologically marked by distinct case categories. There is a canonical NP V (NP) order in main clauses; subordinate clauses, however, occur in NP (NP) V order. On the whole then, a strategy much like that for English would also apply in Dutch, except that, in the formulation of the relevant first stage of processing, a distinction would have to be drawn between main clause and subordinate clause orders. It should also be noted that, rather like German, Dutch main clauses operate on a verb-second principle; that is, constituents of many types can be topicalized with the verb then appearing immediately after the topic, and the remainder of the clause following the verb in otherwise normal order. We will not attempt to specify what consequences the V-second character of Dutch main clause structures would have for a formulation of the precise statement of a CSS for Dutch.

The Experiment

Stimulus materials. To test the predictions of the CSS, we developed a list of 13 simple WH-questions containing five distracter (and learning) sentences and four pairs of corresponding subject and object questions, such as (9):

(9) a. Who is pulling the girl?

b. Who is the girl pulling?

The list began with two warm-up (learning) questions, followed by the eight experimental sentences among which three additional distracter sentences were interspersed. Corresponding subject and object questions were always separated by five intervening sentences. Another list of exact counterpart embedded questions was also constructed and was organized in the same way as the simple questions. On this list, the following pair of sentences occurs as the doppelganger

to (9), for example:

(10) a. Tell me who is pulling the girl.

b. Tell me who the girl is pulling.

Both the simple and embedded question sets were presented in two orders: after the first two warm-up questions, the remaining eleven sentences of each set were put into two inversely ordered lists. Translation-equivalent lists organized in precisely the same way were constructed in German and Dutch. The full list of sentences used in the three languages is provided in the Appendix.

The materials on the basis of which the questions were to be answered consisted of a set of line drawings. The pictures corresponding to (9) are shown in Figures One and Two.

Insert Figure One and Two about here

There were 17 pictures, the first four of which were simply drawings of the individuals that appeared in subsequent stimulus materials, while the remaining pictures represented actions or situations. Among the four pairs of pictures corresponding to the four pairs of experimental sentences, two of the picture pairs represent a non-reciprocal action such as the girl pulling the boy in Figure Two. Two other pairs represent a reciprocal action; for example, one picture shows a man and woman looking at one another. This picture is given in Figure Three. Two copies of exactly this same drawing were then used to elicit the response to the questions (11):

(11) a. Who is the man looking at?

b. Who is looking at the man?

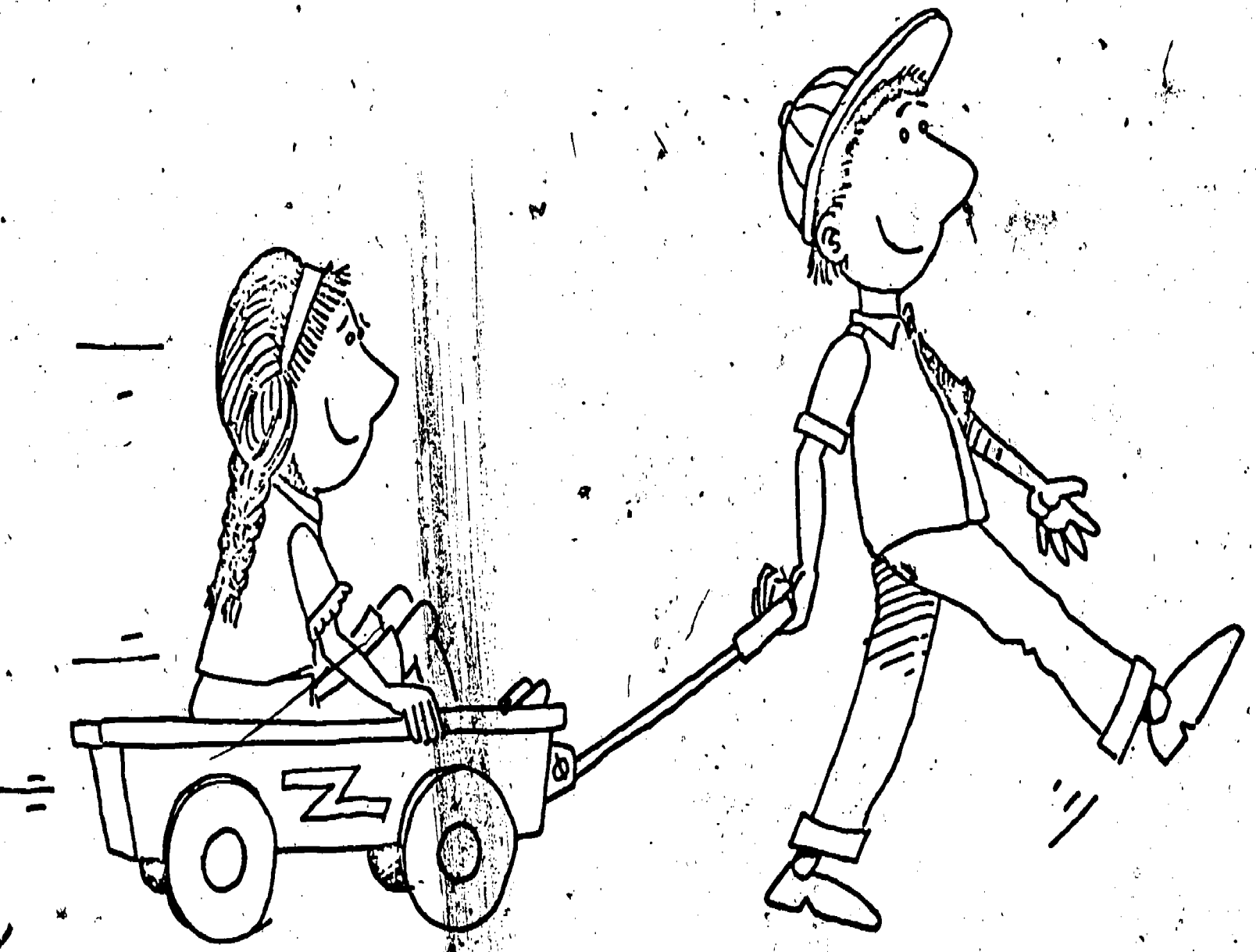

Figure 1. Picture for stimulus sentences (9a) and (10a).

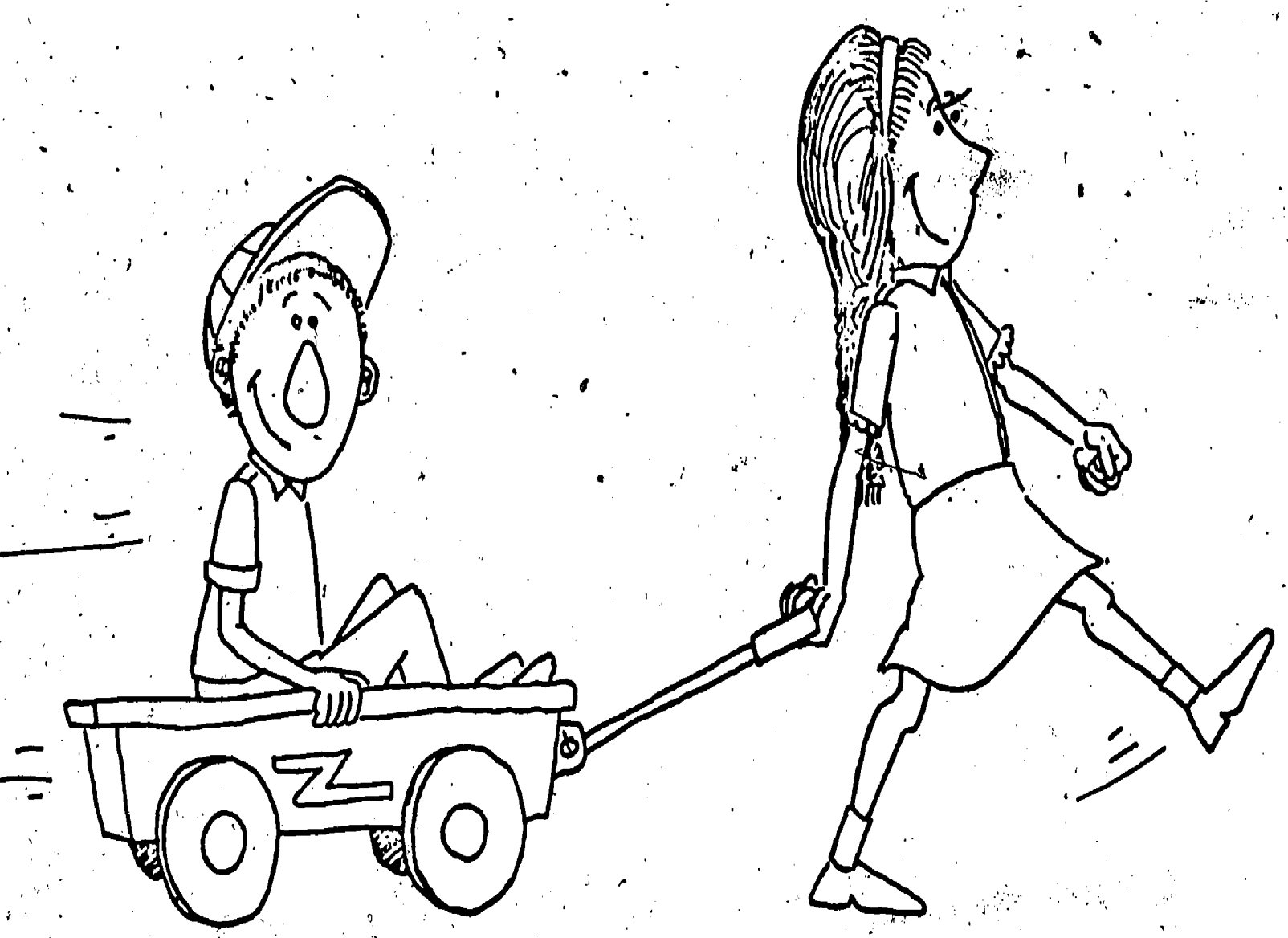

Figure 2. Picture for stimulus sentences (9b) and (10b).

Insert Figure Three about here

The reasons for using both reciprocal and non-reciprocal pairs will be discussed later. Each of the drawings for the eight experimental sentences contained only two individuals, but the warm-up and distracter pictures had from two to four individuals. The corresponding pairs of pictures and questions were designed to elicit the same response; for example, given the drawings in Figures One and Two, both questions in (9) elicit the boy as a correct response. This design was used for reasons discussed below.

The stimulus sentences were recorded under carefully controlled conditions by native speakers of each of the languages. The actual stimulus tapes were then created by computer-controlled playback of the recorded speech. On the resultant high quality tape recordings, a soft tone (40 dB below 0 VU) was inserted exactly two and a half seconds before the onset of every stimulus sentence. There was also a constant interval of eight and a half seconds between the onset of each successive stimulus sentence. The line drawings were collected in two loose-leaf notebooks, to be shown manually to subjects by one of the experimenters. The function of the tone on the tape was to signal the experimenter to show the picture that corresponded to the next stimulus sentence, as well as to alert the S that a stimulus sentence would shortly occur. During the interval between the tone and the following sentence, Ss would thus have an opportunity to examine the drawing. Figure Four schematically represents the organization of the stimulus tapes.

Insert Figure Four about here

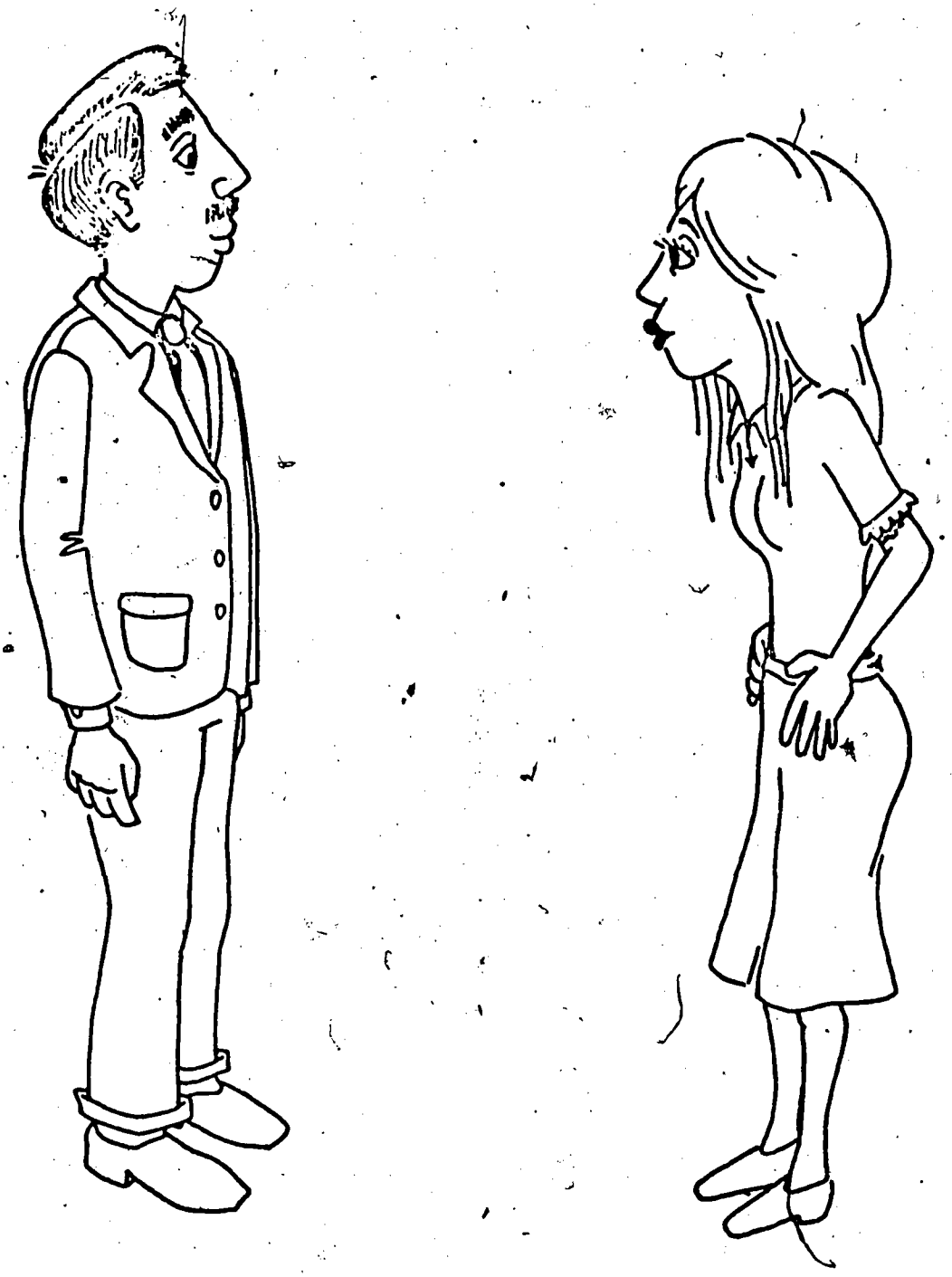

Figure 3. Picture for stimulus sentences (11).

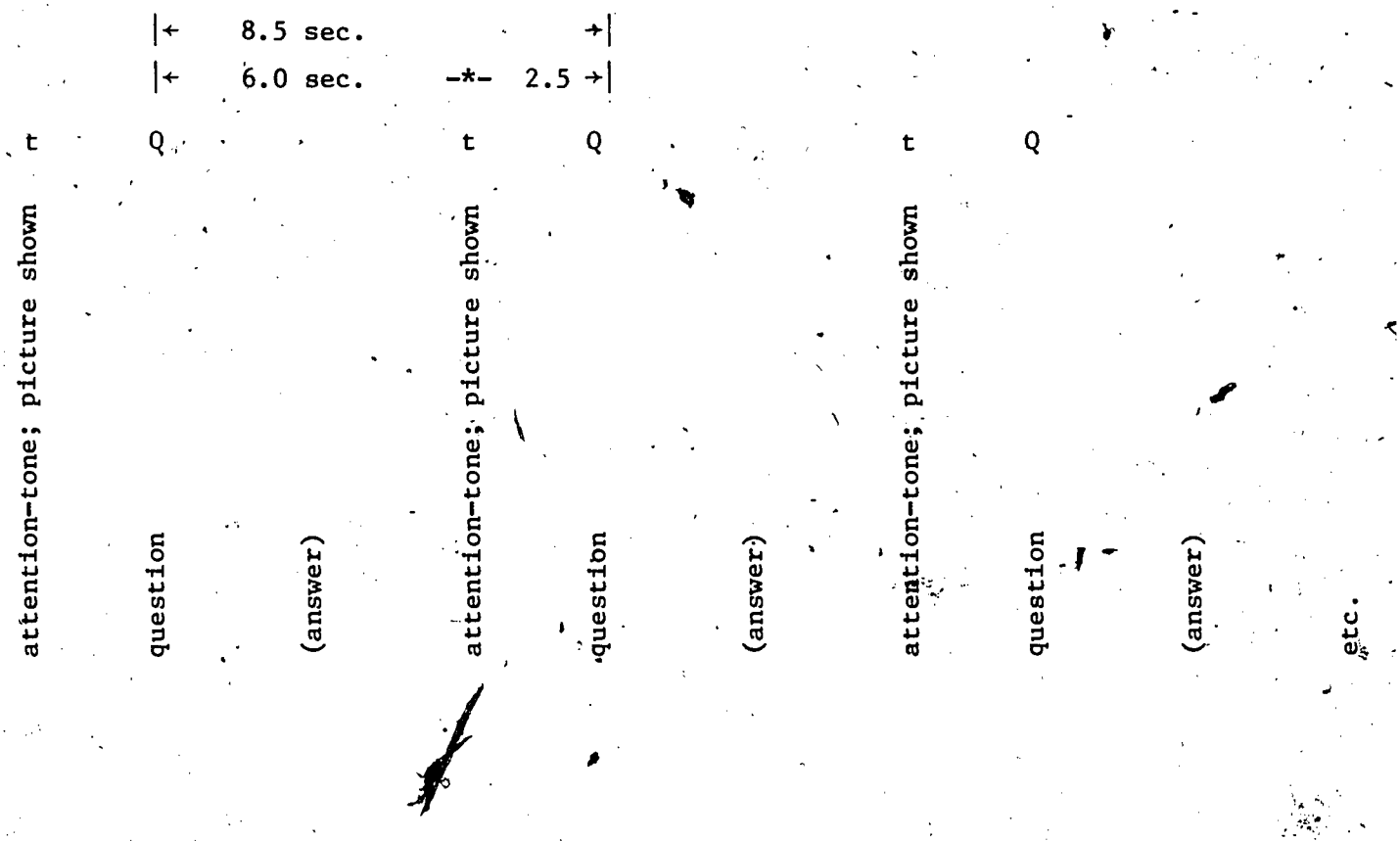

Figure 4. Schematic representation of the organization of the stimulus tapes in all three languages and both question types.

The Ss, who were interviewed individually in a quiet room, were given instructions about the nature of the task. They were told that they would be shown the pictures in the book and that they would hear over headphones a question about each picture. They were asked to answer the question as fast as they could. They were then shown the first four drawings which were representations of each of the people that appear subsequently in the test pictures. Ss were told what each of the people was to be called. After Ss were then given an opportunity to ask questions, the experimental session began.

Equipment. The stimulus sentences were presented over headphones from a Uher 4000 series monophonic tape recorder. Ss responses were recorded on a Uher 4000 series stereophonic recorder. Exactly the same equipment and drawings were used in all the experimental sessions in all three countries where the research was conducted. In order to measure RTs, the dependent variable, the SSR keyboard was used (Stephenson & Roberts, 1977). One of the two channels of the stereo recording unit was used for a standard audio recording of the entire proceedings. The other channel received the output of the keyboard which has a crystal-controlled timing signal with phase-encoded bits representing the onset of the stimulus question and the onset of the S's response. The bits are triggered by an analog-to-digital converter driven by a microphone amplifier. Also encoded on the timing signal were bits representing information manually entered by one of the Es keying in graphic characters at the keyboard. These characters were used to confirm stimulus and response onsets, as well as to encode information such as the S's age and sex, the order of stimulus questions, and the identifying number for each stimulus sentence.

Subjects. The adult subjects were university students. Native English speakers were students at the University of Wisconsin, Dutch speakers were from the Katholieke Universiteit in Nijmegen, and German speakers were students at the University of Cologne. The child Ss were seven-year-olds; the English speakers were first and second graders from the Huegel School in Madison, Wisconsin; the Dutch children were of the same age from the Gabriël School in Nijmegen, and the German children were about a year younger, from the Katholischer Kindergarten in Kranenburg. Only children with normal speaking and hearing were used as Ss.

Observations on experimental design. Since the aim of the research was to collect data on (possible) differences in RT between subject and object questions, both simple and embedded, the primary comparisons were to be made between the RTs for each member of corresponding subject and object pairs such as (9). Therefore, throughout the lists, question types were systematically varied between subject and object; as can be seen by inspecting the lists of sentences in the Appendix, for the experimental sentences, the sequence in one order was O, S, S, O, S, O, O, S, and in the other order the sequence was exactly reversed. As indicated above, both questions in a corresponding S and O pair were to elicit the same response. The reason for this was so that possible differences in RTs would not reflect task-unrelated response bias, such as differences in lexical access.

The choice of two reciprocal and two non-reciprocal pairs was motivated by the following consideration. Correct responses to questions about drawings representing non-reciprocal actions might not reflect a full processing of the stimulus sentence, since it might not be necessary to determine grammatical

relations fully before the appropriate response would become apparent. For example, seeing Figure One and hearing question (9a), Ss might have sufficient information to answer the question by the time they have heard pulling. But in the cases where a reciprocal action was represented in the drawing, it would presumably not be possible for Ss to give the correct response in advance of determining grammatical relations. For example, seeing a drawing of a man and woman looking at one another, a S who hears the question (11b) is unable to choose the correct response until the entire sentence has been heard and the subject/object relations have been identified. The use of both reciprocal and non-reciprocal cases thus constituted a check on differential use of grammatical information.

The ambiguity of the Dutch questions provided an additional motivation for the distinction between reciprocal and non-reciprocal pairs. In a neutral context, the Dutch simple and embedded WH-questions are systematically ambiguous structurally, although as suggested earlier, there is a marked preference for subject interpretation in actual use. Even with the prosodic cues that favor an object interpretation, Dutch speakers impose subject interpretations about 72% of the time in a neutral context. Therefore, the contrast between reciprocal and non-reciprocal pairs becomes quite interesting because in the latter an object interpretation may be forced by the picture while in the former it is not. For example, given the picture of the girl pulling the boy, as in Figure Two, and question (12), an object interpretation of the question is clearly required:

(12) Wie trekt het meisje? 'Who pulls the girl?'

viz. Who is the girl pulling?

On the other hand, given a picture of a man and woman kissing one another, and question (3a), neither the picture nor the question force a particular interpretation; the question remains ambiguous.

A final, and important, methodological observation should be made concerning what is being measured by RTs in this experiment. Clearly, the RTs obtained are not a direct reflection of on-line processing. In terms of the two major categories of experimental tasks identified by Levelt (1978), the design used here, question-answering, belongs to the "successive measurement" rather than the "simultaneous measurement" category. The latter type, which can be claimed to offer potential direct evidence about on-line processing, involves, according to Levelt (p. 4), "procedures where measurement takes place during reception of the stimulus," whereas the former type, which in principle can offer only potential indirect evidence about processing, involves "procedures where measurement takes place after presentation of the stimulus." The interval which we measured was from the onset of the stimulus sentence to the onset of the response; during this time the subject hears and presumably comprehends the question, seeks out the necessary information for responding, composes an answer, and starts to produce it. The RT results cannot directly distinguish these distinct tasks, for the results are the sum of, at least, comprehension, memory, and production. However, since memory and production are held constant within members of corresponding pairs, comprehension (as it relates to grammatical structure) is the major variable reflected in RT differences.

Results

For each trial, we measured the interval between the onset of the question and the onset of the answer, on the assumption that the comprehension process begins at the beginning of the question. This measurement was primarily by an automatic process, in that the timing signal produced by our SSR keyboard (with markers for the onset of the stimulus and the onset of the response) was decoded from the tape recording by a computer program. The output of this computer program was a listing such as that shown for one trial in Figure Five, where the first "STI" and the first "RES" mark the onset of the stimulus and response respectively. This decoding facility is implemented on a Harris 6024/5 Computer at the Wisconsin Research and Development Center, and has been described in Stephenson and Roberts (1977). The third column in Figure Five shows the time in twentieths of a second; thus the interval from onset to onset in this case is (2506 - 2474)/20 or 1.6 seconds.

Insert Figure Five about here

In certain instances, we measured the interval manually from the audio channel of the tape recording, i.e., by moving the tape slowly past the playback head, marking on the tape itself the onset of the question and the onset of the answer. We did this in cases where the printout was obviously in error, such as where no response was indicated on the printout but where a correct response was audible in the recording, and in an approximately one-tenth random sample of data, to check the reliability of the automatic method. The two methods agreed to within rounding error in all but a handful of cases.

```
155   0:02:01.5     2430 /12
156   0:02:03.7     2474 STI
157   0:02:03.8     2477 ?
158   0:02:03.9     2478 STI
159   0:02:04.3     2485 STI
160   0:02:04.4     2489 STI
161   0:02:04.5     2491 STI
162   0:02:04.6     2493 STI
163   0:02:05.3     2506 RES
164   0:02:05.6     2512 %
```

Figure 5. Sample of output from automated procedure for determining response times. "/12" means question 12 for this listener; "STI" and "RES" indicate signals on the stimulus and response channels, respectively. "?" and "%" are manually-entered from the keyboard by the experimenter, to verify the onset of the question and the answer, respectively.

We believe that our manual measurements provided at least as fine a resolution as the automatic ones, since at the speed used, one-twentieth second equals approximately 2.4 mm of tape. Hence we measured intervals to the nearest one-twentieth second, subject to error of at most five percent for variation in tape speed and for rounding.

We then subjected the data to the following constraints:

-that only intervals for correct responses were included; substitutions like "the father" for "the man" and "the mother" for "the woman" were accepted, as were article-gender errors by Dutch and German children. All other non-standard responses were treated as missing.

-that all response intervals of 3.5 seconds or longer were treated as missing. Values this long occurred only in the Dutch data in response to the ambiguous questions and the forced object interpretations. We assume that in intervals this long, some additional processing is taking place.

-that answers preceded by pause-fillers such as "uhm" and "er," coughs, or other vocalizations were treated as missing, since we could not assume that the onset of the answer came as early as possible.

The data thus selected make up the basis for the results reported below. We will first describe the outcomes for adults only and then make comparisons with children.

Main effects. A three-way analysis of variance (Qtype x subject/object x verb, with repeated measures on subject/object) shows that in all three languages the response times to subject and object questions differ significantly. What is striking is that the direction of these differences is not the same across languages: subject-questions are answered faster in Dutch and German, but object-questions are answered faster in English. Essentially the same results appear

when one subtracts the length of each question from the response times, in effect measuring from the end of the question to the beginning of the answer.

Insert Table One about here

(We think that the former measure is the correct one, but the latter shows that the differences we observed are not merely the result of differences in the duration of the questions themselves.)

Consistency. Though the overall difference between subject-questions and object-questions is large and reliable according to the repeated-measures analysis of variance, it is not entirely consistent across the four verbs or across individual speakers of a language.

Let us consider consistency across verbs by language. In English, object-questions were answered faster for all four verbs in both simple and embedded questions, except for kiss in simple questions. This difference was significant only for look in simple questions and pull in embedded questions, however. Table Two (below) summarizes these differences, with t-tests, for all three languages, all four verbs, and both question forms. In German, subject-questions were answered faster for all verbs in both question-forms except for kiss (küssen) in simple questions and look (anschauen) in embedded questions. In Dutch, we will consider only chase and pull (achternazitten and trekken), because the questions with look at and kiss were ambiguous, with no distinction except intonation between "subject" and "object" forms. (Read, Kraak, and Boves (1979) suggest that these questions were interpreted as subject-questions on most trials, with a slight effect of intonation.) As for chase and pull in Dutch, the subject-question advantage held for both question-types, except for chase in simple

Table 1

Response Times to Subject- and Object-Questions:
Included are Adults for Whom no Values were Missing.
Values are in Twentieths of a Second.

	English				Dutch				German			
	Simple		Embedded		Simple		Embedded		Simple		Embedded	
Total RT	subj	obj	subj	obj	subj	obj	subj	obj	subj	obj	subj	obj
$\bar{X}$	31.2	29.6	34.4	33.5	38.6	41.9	39.9	44.2	32.1	33.0	43.2	44.8
s.d.	4.4	4.7	6.4	5.9	8.0	8.8	5.4	7.9	6.7	6.8	5.9	7.1
F,p	14.9; p <.001				31.9; p <.001				8.5; p <.005			
RT - Stimulus length												
$\bar{X}$	13.1	11.2	16.3	15.1	13.4	16.5	14.7	18.9	8.6	9.1	19.7	20.9
s.d.	4.4	4.7	6.4	5.9	8.0	8.8	5.4	7.9	6.7	6.8	5.9	7.1
F,p	23.1; p <.001				29.4; p <.001				4.3; p <.05			
n	24		25		14		14		39		27	

questions. In summary, for each of the six columns of Table Two (three languages x two question-types), there are at most two verbs for which the subject-object difference was significant.

Insert Table Two about here

Similarly for consistency across listeners: in English one finds a clear majority who answered object-questions consistently faster, but a minority who answered subject-questions faster, and conversely for Dutch and German. The existence of a minority in each language, from 4.5% in Dutch to 25.5% in German, who were consistently faster on the form for which their language-peers were slower, indicates that the processing advantage is not absolute.

Insert Table Three about here

Children. The main effects for children in all three languages are similar to those for adults. In English, the same repeated-measures analysis of variance as was applied to the adult data shows a significant advantage for object-questions ($F = 10.99$, $p < .003$). The English-speaking children answered the object-questions faster with all verbs, but this difference reached significance only for look in embedded questions and kiss in both question-types. (See Table Four.) With German and Dutch children, only simple questions were tested. German children answered the subject-forms more rapidly with all verbs, but this difference was not statistically significant overall ($F = 2.26$, $p = .16$) nor for any verb individually. (We had a somewhat smaller sample of children and of valid trials with German children.) For Dutch children, the

Table 2

Mean Differences in Response Time to Subject- and Object-Questions for Adults. For a Missing Value, only the Subject/Object Pair for that Verb was Omitted.

	English		Dutch		German	
	Simple	Embedded	Simple	Embedded	Simple	Embedded
look						
n	25	25			45	29
faster	obj	obj			subj	obj
mean diff	.19	.06			.05	.13
t,p	3.91 <.001	ns			ns	ns
chase						
n	25	27	20	26	45	31
faster	obj	obj	obj	subj	subj	subj
mean diff	.09	.05	.002	.27	.05	.12
t,p	ns	ns	ns	3.20 <.004	ns	3.80 <.001
pull						
n	25	27	27	26	39	30
faster	obj	obj	subj	subj	subj	subj
mean diff	.05	.06	.37	.47	.10	.05
t,p	ns	2.17 <.04	2.97 <.01	5.09 <.001	2.22 <.032	ns
kiss						
n	24	27			44	31
faster	subj	obj			obj	subj
mean diff	.03	.01			.04	.13
t,p	ns	ns			ns	2.02 <.053

Table 3

Number and Percent of Listeners Giving Faster Responses to Subject- or Object-Questions, by Language. Included are Adults From Both Question and Embedded-Question Conditions for Whom No Values Were Missing

		English	Dutch	German
Majority subject faster	n	4	17	23
	%	13.8	77.3	49.0
Neither	n	7	4	12
	%	24.1	18.2	25.5
Majority object faster	n	18	1	12
	%	62.1	4.5	25.5
Totals		29	22	47

results take a slightly different form, but they still accord in general with the outcomes for adults.

Insert Table Four about here

Recall that in Dutch, we actually disambiguated the questions only with chase and pull, so that it is only for these verbs that we can compare subject- and object-questions. With both verbs, Dutch children answered the subject-questions significantly faster. (See Table Four.) It was not meaningful to carry out the repeated-measures analysis of variance for the data as a whole, because in that procedure, entire cases with missing values are deleted, and there were many missing values from the Dutch children, primarily in response to questions for which the picture forced an object-interpretation. Some of the Dutch children, in fact, apparently could not assign object interpretations in such cases, and as a result said, "Dat klopt niet!" ("That doesn't make sense!") or gave no response. In some instances, these children answered in the following way:

Q: Who is the girl pulling?

A: The girl.

i.e., they answered as if they had assigned a subject-interpretation to who, regardless of the fact that the picture forced an object-interpretation. In other words, it appears that some of these Dutch six- and seven-year-olds have overgeneralized the preference for subject-interpretation of these questions: they require a subject interpretation. In all, we got silence, the wrong noun, or "Dat klopt niet" from 9 out of 26 Dutch children in response to the counterpart of "Who is the girl pulling?" and from 12 out of 26 in response to "Who is the

Table 4

Mean Differences in Response Time to Subject- and Object-Questions for Children. For a Missing Value, only the Subject/Object Pair for that Verb was Omitted.

	English		Dutch	German
	Simple	Embedded	Simple	Simple
look				
n	20	14		17
faster	obj	obj		subj
mean diff	.08	.28		.03
t,p	ns	2.66 <.02		ns
chase				
n	23	21	11	17
faster	obj	obj	subj	subj
mean diff	.02	.11	.77	.14
t,p	ns	ns	4.25 <.002	ns
pull				
n	22	20	12	14
faster	obj	obj	subj	subj
mean diff	.12	.14	.47	.21
t,p	ns	ns	3.98 <.002	ns
kiss				
n	21	17		18
faster	obj	obj		subj
mean diff	.16	.31		.15
t,p	2.18 <.04	3.55 <.003		ns

boy chasing?" while some of the youngest and some of the oldest children in our sample gave correct answers. Irene Vogel and her colleagues have confirmed this observation with children in Amsterdam from 4 to 12 years old. The eight-year-olds (only) gave no object-interpretation to questions like these in a picture-interpretation task (Vogel, Bensink, Bol, van der Flier, & Nagtegaal, 1979). This over-generalization occurs much later than the better-known morphological over-regularization in young children's language.

Null effects. There were no significant differences by sex, according to the same type of repeated-measures analysis of variance. This suggests that our counter-balancing of man/woman/boy/girl succeeded in avoiding biases in distribution or roles of the sexes that might have affected responses.

There were also no effects of the two orders of presentation, among the English or German speakers, but there was a significant effect among Dutch adults ($F = 4.5$, $p = .045$). In the data, we find a few unusually large differences between the subject and object forms for pull which occurred primarily in one order. We think this effect, though real, is idiosyncratic.

Problems. The subject-advantage in German and Dutch is parallel to the observation that languages are more likely to be able to question or relativize subjects than objects (Keenan & Comrie, 1977). That is, both the tendency among languages and the processing advantage may reflect a basic preference for questioning subjects rather than objects. From this point of view, what is striking is that our results for English run counter to this preference. Before we consider putative explanations for these results, we must consider the possibility that they are simply not valid. There is a way in which they might be artefactual.

Recall that all of our test questions, though not the distracters, referred to pictures in which there were only two people: a man and a woman or a boy and a girl. Let us assume that our listeners quickly noticed this fact and inferred that when one member of a pair was explicitly mentioned in a question, the referent for who must be the other one. Given a picture with the boy and the girl, if you are asked,

Who is chasing the boy?

you can infer without reference to any part of the question other than "the boy," that the answer must be "the girl." Now given,

Who is the boy chasing?

you can make the same inference, but the crucial cue, "the boy," comes earlier in the question. This difference could lead to an artefactual object-question advantage in English and not in German or Dutch.

The best way of ruling out this "other noun" strategy would be to redo the experiment, using pictures with multiple people (and other changes). We plan to do just that. But even without the results of a second experiment, there are some relevant considerations. First, it is notable that to assume that listeners adopted the "other noun" strategy is to assume that given the opportunity, they quickly set aside their usual way of comprehending questions and adopted a new one suited only to this situation. We don't doubt that listeners adapt their comprehension to circumstances, but we doubt that both adults and children would do it so quickly with so little provocation.

A related question is whether listeners' strategies appeared to change during our list of questions. If the object-advantage in English is a result of normal comprehension processes, then it should be more or less constant

through the list. If it is the result of an "other noun" strategy, then it might very well develop during the list, since that strategy would not work with our introductory questions.

In fact, whether one measures the total reaction time or just that portion after the end of the question, there is no monotonic increase in the object advantage for English. In general, the second object-question is answered faster than the first one (in fact, the second question of either kind is answered faster than the first one), but beyond the second instance, there is no general speed-up in response to object-questions. We have examined response times and the object advantage in relation to order of presentation in considerable detail, but we have been unable to either confirm or disconfirm the "other-noun" strategy, mainly because when the object advantage does increase across order of presentation, it is consistent with a general but irregular tendency for all responses to speed up. This tendency occurs in German, as well as in English.

In sum, the "other-noun" strategy remains a possibility that would have to be disconfirmed before one could be certain of the object advantage in English and the contrast between English and the other two languages. That hypothetical strategy is not supported by an increasing object advantage across the order of presentation, however.

One other extraneous factor may be worth considering, namely the possible influence of sex-role expectations in the interpretation of reciprocal pictures. In Read, Kraak, and Boves (1979), Dutch adults showed no significant sex-role biases in their interpretation of questions with these and four other verbs. However, such a bias may have slightly affected our results. For reciprocal

actions (only), such as the picture of a man and a woman kissing each other, the listener may expect one person or the other to be the agent. Indeed, the subject-question, "Who is kissing the woman?" elicited non-significantly faster responses than its object counterpart, whereas for all other questions in English (in both question-types and at both ages), the object question was answered faster. Possibly an expectation by adults only, that when a man and a woman kiss, the man is the initiator (i.e., the agent), may contribute to this sole exception. This is the only indication of sex-role bias that we have found in our results, however, and it accounts for at most a slight difference.

Discussion

As best we can determine, our results, especially those for English, are not consistent with any purely syntactically-based model of sentence processing. Obviously, the outcome in English gives no support whatever to the CSS. Similarly, processing models of the ATN sort described in Wanner and Maratsos (1978), at least as discussed in that work and others like Wanner (1980), do not predict the kind of outcome we obtained. (However, Wanner and Maratsos acknowledge that contextual or semantic information may in certain circumstances permit comprehension to take place with little syntactic analysis; we return to this point subsequently.) The ATN model (and also the general principle of parsing that Fodor 1979 proposes) would predict that the greater the distance between a WH-word and the subsequent "gap" which it fills (or binds), the more the processing load in the region between filler and gap. Moreover, one might expect, ceteris paribus, that the sooner the gap can be filled (bound), the quicker the sentence can be successfully processed and responded to. Thus, using the conventional representation of the gap, it is clear that the gap can

be filled earlier in (1a), repeated below as (13), than in (1b):

(13) a. Who Δ is kissing the woman?

b. Who is the woman kissing Δ?

It would seem that any syntactically-based linear procedure for assigning fillers to gaps predicts greater ease and probably speed for subject- than for object-questions, especially if the processor has a limited (one or two word) "look ahead" capacity - cf. Kimball (1973) and Frazier and Fodor (1978). Wanner and Maratsos found support for the greater ease of processing subject relatives than object relatives, thereby supporting their suggestion (121) that "at least in some circumstances, . . . functional information is determined syntactically during comprehension." The task we set our subjects appears to have brought evidence to bear on a further question they raise, namely whether their predictions about syntactic processing hold up when semantic or contextual information is added.

If we consider examples (13a) and (13b) with reference only to the structure of the sentences and the context (namely, the reciprocal picture), it should be clear that even when the filler for the gap in (13a) has been identified, there is not enough information to determine the referent of who until the final NP the woman has been processed. The picture does not permit the identification of the agent, even with knowledge of the verb. But in (13b), on the other hand, once a S has heard the subject NP the woman, he can determine that who must pick out the man. The S could determine this either by the "other noun strategy" or by some variant such as the following: the S sees that the picture involves two individuals, the man and the woman, engaged in the act of kissing one another. In the course of hearing question (13b), by

the point that the phrase the woman is received, the S effectively has as much information as he needs to determine grammatical relations: the picture represents two (and only two) individuals engaged in a reciprocal action; given the structure of the question through the woman, the S can determine that the woman must be the subject and that who must therefore pick out the object. Hence, the S has sufficient information at this point to answer the question, even without knowing certainly what action the question will ask about (e.g., the verb could have been holding instead of kissing, and the answer would be the same).

On the other hand, in questions like (9), repeated below as (14), since the picture represents a non-reciprocal action, the situation of the S is different:

(14) a. Who Δ is pulling the girl?

b. Who is the girl pulling Δ?

In this case, the S has sufficient contextual and grammatical information to answer both questions before they are completed. The answer to (14a) can be deduced by the point the S hears pulling, since given the form of the question he can determine that it is asking for the identity of the subject (agent), and that the action is non-reciprocal. In a different way, the answer to (14b) can be deduced by the point the S hears the girl; who must refer to the other noun, i.e., the object. Note that in the non-reciprocal pairs, the answer is deducible at approximately the same temporal point in the sentence; the (mostly nonsignificant) object advantage found in these cases may be due to the probably greater semantic complexity of verbal versus nominal structure. It is plausible to assume that it takes longer to compute a reading for pulling than

for the girl, so that the semantic and contextual information sufficient to answer (14b) is most likely available slightly sooner than it is for (14a).

Our results were generally consistent with this story, and would thus seem to argue for an on-line interactive model of processing which brings to bear all the available sources of information (syntactic, semantic, and pragmatic) in parallel. Such a view of sentence processing has been proposed by Marslen-Wilson, Tyler, and Seidenberg (1978). As described there (p. 219), "This approach claims, in essence, that the listener attempts to interpret fully each utterance word-by-word as he hears it," bringing lexical, syntactic, semantic, and non-linguistic information jointly to bear in the comprehension process. And while our task clearly does not offer direct evidence about on-line processing, the pattern described above is consistent with the picture of on-line interactive processing rather than a syntactically-based model.

Looked at from this perspective, the results from English-speaking children come close to meeting the predictions of the interactive model. Comparing reciprocal with non-reciprocal verbs in both question-types, we find that in three of the four cases with reciprocal verbs, the object advantage is large and statistically significant, while in all the non-reciprocal cases, there is an object advantage, but it is small and nonsignificant. On the other hand, the adult English-speakers' performance is less consistent in detail with this story. As suggested above, this may be partly due to a response bias with respect to the kiss-sentences, but the fact is that only one of the four reciprocal verbs shows significant object advantage. Moreover, there is a marginally significant object advantage for one of the non-reciprocal verbs. We are quite frankly puzzled by this aspect of the results, since they seem to fit

no one's model precisely. With this reservation, however, we think the results as a whole are most consistent with the view that sentence comprehension identifies probable referents as early as possible in the presentation of the string, using contextual and semantic information as well as syntactic. One such view is that of Marslen-Wilson et al. (1978), though some syntactically-based parsers have allowed for the contribution of non-syntactic information as well.

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Appendix

On the next page appears the full set of simple questions used in the experiments. The embedded question lists were identical except for the changes required to convert the sentences into the proper indirect question form. For English, this involved embedding the questions into the frame Tell me . . . and moving the auxiliary in object-questions directly before the main verb. For Dutch, the comparable change required the introduction of Zeg me . . . and the placement of the finite verb at the end of the interrogative clause. In German, the embedded questions are structured just like the Dutch ones; they are introduced by Sag mir . . .

English	Dutch	German
1. Who is the biggest?	Wie is het grootst?	Wer ist der grösste?
2. Who did the cat scratch?	Wie krabde de kat?	Wen kratzte die Katze?
3. Who is the woman kissing?	Wie zoent de vrouw?	Wen küsst die Frau?
4. Who is pulling the girl?	Wie trekt het meisje?	Wer zieht das Mädchen?
5. Whose bubble is smallest?	Wie heeft de kleinste ballon?	Wer hat den kleinsten Ballon?
6. Who is chasing the boy?	Wie zit de jongen achterna?	Wer verfolgt den Jungen?
7. Who is the man looking at?	Wie kijkt de man aan?	Wen schaut der Mann an?
8. Who is he giving the letter to?	Wie geeft hij de brief?	Wem gibt er den Brief?
9. Who is kissing the woman?	Wie zoent de vrouw?	Wer küsste die Frau?
10. Who is the girl pulling?	Wie trekt het meisje?	Wen zieht das Mädchen?
11. Who is the book near?	Bij wie ligt het boek?	Neben wem liegt das Buch?
12. Who is the boy chasing?	Wie zit de jongen achterna?	Wen verfolgt der Junge?
13. Who is looking at the man?	Wie kijkt de man aan?	Wer schaut den Mann an?

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